WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY (WDEQ)

SOLID AND HAZARDOUS WASTE DIVISION (SHWD)

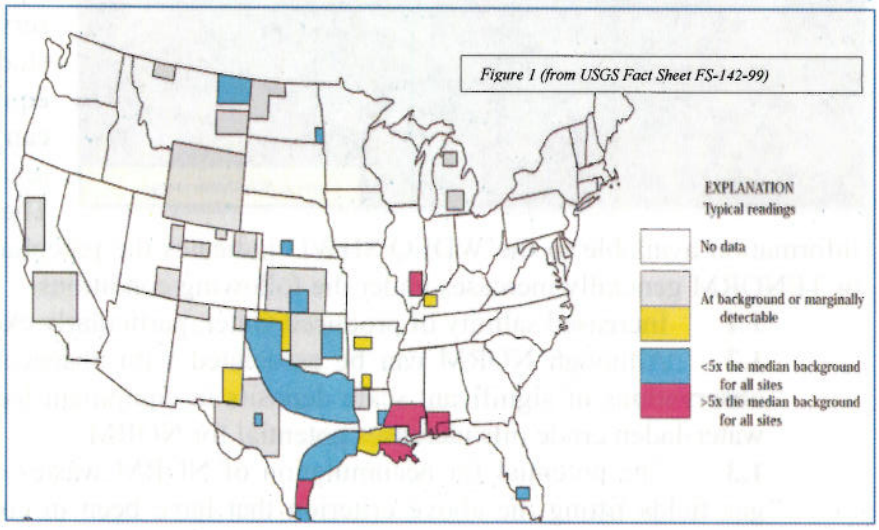
GUIDELINE # 24
NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM) MANAGEMENT IN WYOMING

1.0 Introduction

This document provides guidelines to identify and manage NORM wastes that may be generated by facilities within the state of Wyoming. The SHWD defines NORM as:

"Any waste material exceeding the greater of natural background levels found in nearest non-impacted natural soils at the surface or 8 picoCuries per gram (pCi/g) radium-226 and/or decommissioned equipment from crude oil and/or gas operations exceeding 50 microRoentgens per hour (μR/hr) emanation rate at any accessible point. Any waste exceeding these thresholds is subject to controls and guidance by SHWD."

The SHWD believes that regulation of NORM at these thresholds is supported by Wyoming's existing statutes and regulations. NORM is considered a solid waste and, as such, subject to existing SHWD regulations and authority.



NORM wastes are more frequently associated with longer-term handling of salt-laden water containing relatively higher levels of Total Dissolved Solids (TDS) flowing to the surface with crude oil and/or natural gas. NORM may also be referred to as Technologically Enhanced NORM (TENORM). This term acknowledges natural background sources of

radiation are always present, but many industrial activities can concentrate or "enhance" these natural sources. As shown on **Figure 1**, the U.S. Geological Survey and other published sources indicate NORM is encountered less frequently in Wyoming than states such as Texas, Louisiana and Kansas.

Other states have more extensive experience with NORM management compared to Wyoming. Therefore, this guidance is based, in part, on experience of these other states. WDEQ/SHWD has attempted to supplement guidance and information we obtained from other states with a general review of radiation concepts and "rules of thumb". Radiation concepts can be confusing and appropriate management may be difficult unless some fundamentals of radiation and its measurement are understood. SHWD also realizes any document addressing something as complex as radioactivity is likely to evolve with future corrections, clarifications, etc.

NORM wastes can include, but are not limited to scale and/or sludge generated as a distinct waste from maintenance activities. These activities can include removal of material adhering to pipes, heater-treater/separator vessels, storage/transfer tanks, dehydrators, heat exchangers, valves, and other equipment used to pump, transfer, store or otherwise handle produced waters or crude oils containing significant levels of water. This usually occurs before "lease automatic custody transfer" or other legal custody transfers. Radon can be a component of NORM and can be present in produced water with release to the atmosphere when fluids go from higher formation pressures to lower pressure at the surface. Radon and its radioactive daughter products can also be associated with gas processing, particularly reflux pump equipment, since radon's physical properties resemble some light petroleum gases (ethane/propane). Any equipment at the end of its service life with scale and/or sludge still adhering to the equipment at decommissioning can also constitute NORM wastes (example shown on **Figure 2**).

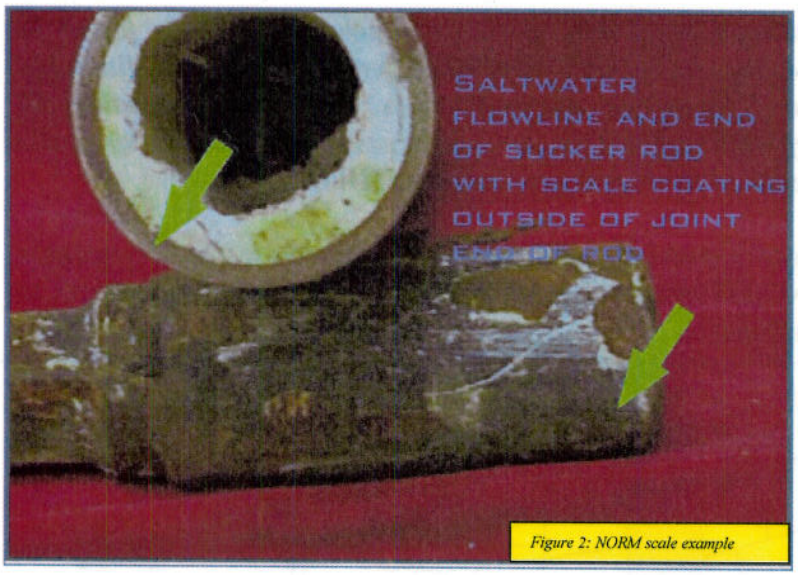


Figure 2: NORM scale example

There are exceptions, but information available to the WDEQ/SHWD indicates the potential for accumulation of NORM or TENORM generally increases under the following conditions:

1.1 Increased salinity of produced water, particularly exceeding 10,000 mg/l TDS.

1.2 Although NORM can be associated with absence of visible scales or sludges, observations of significant scale deposits in equipment handling produced water and/or water-laden crude oils increases potential for NORM.

1.3 The potential for accumulation of NORM wastes can increase with older oil & gas fields fitting the above criterion that have been in commercial production over 30 years.

The above information is provided as a preliminary evaluation of NORM potential. The SHWD cannot, nor does it have the responsibility to, evaluate site-specific potential or presence of NORM/TENORM. This is the responsibility of owner/operators engaged in activities that may generate NORM/TENORM.

There are numerous units used for measuring radioactivity. Other entities' published guidelines and/or rules may provide thresholds/limits in varied measurement units, and the regulated community may not be clear on just what aspect of radioactivity is assigned a threshold or limit. WDEQ suggests it may help to keep in mind the distinctions between five basic radiological concepts and the measurement units that can be associated with each. These five important concepts are: **radioactivity, concentration, surface activity, exposure** and **dose equivalent** and have the following WDEQ interpretations:

(a) Radioactivity is primarily a result of the instability of the atomic nucleus in natural or manmade elements. Radioactive disintegrations at the atomic level occur for the nucleus to reach more stable conditions with measurement units in "picocuries" (pCi) or standard international (SI) units of "becquerels" (Bq).

(b) Concentrations of specific radioactive elements, such as radium-226, are often measured in "picocuries per gram" (pCi/g) or "becquerel per gram" (Bq/g) in an environmental sample.

(c) Surface activity can give an indication of radioactivity over a given surface area often measured in "becquerel per 100 square centimeters" (Bq/100 cm^2).

(d) Exposure may be viewed as measurement of unqualified exposure rates and/or levels of energy intensity/frequency of radioactive emissions often measured in "microRoentgens" (μR) and/or exposure per unit time (μR/hr) for gamma emissions.

(e) Dose equivalents may be viewed as measurements correlating the radiation to impacts on biological systems and is often measured in "rem," "milli-rem" or "milli-sieverts" (mSv).

Radiation source and type are factors in the measurement concepts discussed above. These include, but are not limited to radium-226 and other radionuclides potentially emitting high energy wavelength gamma and x-rays or materials with actual particle emissions such as alpha, beta and neutron (neutron emissions are often associated with nuclear power plant fuels). The reader should consult other references for more information regarding radiation sources, types, and measurements.

2.0 NORM solid wastes and/or media vs. NORM equipment

There is a distinction between volumetric media such as NORM-contaminated soils, scale, sludge and/or tank bottoms (wastes) vs. equipment where the NORM wastes have not been removed from the equipment. In some cases, owner/operators may choose to remove scale and/or sludges from piping or other equipment, resulting in the generation of a separate,

discernible solid waste where potential NORM may warrant test results on a concentration per unit mass. An example of this is testing the solid waste for pCi/gram radium-226 either as a separate waste removed from the associated piping equipment or a sample taken from the equipment. The SHWD recommends consideration of wet removal methods and respiratory protection to minimize airborne dust to those in the vicinity.

Piping and other equipment that may exhibit radiological activity can be managed with or without removing the visible source radiological material adhering to the equipment in the form of scale, sludges, etc. Guidelines and regulations in other states and industry convention have established field instrument methods to detect emissions or general exposure rates (not concentration or dosage) for NORM equipment. Survey results for steel piping and/or other equipment are often not expressed in concentration per unit mass (e.g., pCi/g). Instead, potential NORM contamination adhering to equipment can be measured by field instruments detecting discrete "counts" of radioactive emission or gamma emanation rates such as μR/hr or specific instrument "counts per minute", which can be correlated/converted to μR/hr. This can more quickly assess whether enough radiological material is adhering to or otherwise integrated into the equipment to indicate NORM/TENORM.

Radiation surveys and/or sampling should be done in accordance with industry conventions found in Nuclear Regulatory Commission (NRC) and "multi-agency" guidance (NUREG-1575).

3.0 Considerations and Management Thresholds for NORM/TENORM

SHWD is not proposing regulations requiring NORM/TENORM analysis of all relevant oil & gas wastes or equipment, particularly given evidence to date does not indicate a significant problem in Wyoming. It is the responsibility of any waste generator to know about their wastes and to manage them appropriately. Generators should also be aware there are primarily two methods to characterize a given waste: (1) analytical testing; and/or (2) assert/apply generator knowledge of a particular waste based on defensible and demonstrable factors. When significant uncertainty exists and/or there is a lack of information to assert generator knowledge, it is the generator's responsibility to test the materials by approved analytical methods.

It will be the general policy of SHWD to evaluate enforcement under existing statutes or regulations if a waste generator has neglected basic NORM/TENORM waste evaluations resulting in inappropriate management of potentially hazardous materials. Examples of such neglect may include, but are not limited to incidents where cases 1.1, 1.2 and 1.3 above are applicable and the generator did not follow through with more thorough identification of NORM/TENORM potential. Additional examples may include, but are not limited to incidents where a metal salvage facility has rejected material due to radiological emanation rates exceeding 50 μR/hr followed by no further evaluation of NORM/TEMORM levels by the generator. SHWD recommends potential generators review conventional, industry knowledge for NORM/TENORM, including the American Petroleum Institute (API) Bulletin E2, Second Edition, April 2006 or the most current edition of this industry publication.

With the above information in mind, the SHWD establishes the guidelines below for management of NORM/TENORM wastes or equipment in Wyoming.

3.1 NORM Waste Management (soils, scales, sludges as solid waste)

3.1.1 If waste sample results indicate concentrations between background levels found in the nearest, non-impacted natural soils at the surface and 30 pCi/g of radium-226 in any wastes, up to 20 cubic yards may be disposed in State-permitted solid waste disposal facilities with approval from the landfill operator. The receiving landfill and SHWD shall be notified for a case-by-case determination of any volumes exceeding 20 cubic yards from any single generator or transporter within any 90-day period. This is not an allowance for "unrestricted use" of any such waste since Wyoming Solid Waste Rules and Regulations (SWRR) still apply to any solid wastes including, but not limited to the prohibition on free liquids in wastes.

Any wastes in the above category should be stored in enclosed containers, durable synthetic fiber "super sacks" or equivalent for a period not to exceed 1 year without prior written authorization from SHWD.

3.1.2 If the waste sample results indicate concentrations between 30 – 50 pCi/g of radium-226, up to 10 cubic yards of the waste may be disposed in State-permitted solid waste disposal facilities with approval from the landfill operator. The waste must be covered upon receipt at the landfill with a minimum 4 feet of approved cover material. The SHWD shall be notified for a case-by-case determination of any volumes exceeding 10 cubic yards from any single generator or transporter within any 90-day period.

Any wastes in the above category should be stored in enclosed containers, durable synthetic fiber "super sacks" or equivalent for a period not to exceed 180 days without prior written authorization from SHWD.

3.1.3 NORM/TENORM wastes exceeding 50 pCi/g of radium-226 cannot be disposed in conventional solid waste facilities in Wyoming and must be managed at facilities outside Wyoming authorized to accept such low-level radioactive wastes. Regulations of the Occupational Health and Safety Administration (OSHA) require all employers to evaluate radiation hazards and post caution signs where radiation doses could exceed 5 millirem in one hour or 100 millirem in any five consecutive days.

Any wastes in the above category should be stored in enclosed containers, durable synthetic fiber "super sacks" or equivalent for a period not to exceed 90 days without prior written authorization from SHWD.

3.2 NORM Equipment Management

3.2.1 If piping and/or other equipment monitoring indicate radiological emanation rates

less than 50 µR/hr or equivalent in other measurement units from decommissioned equipment at any accessible point, the equipment should be recycled. However, up to 20 tons may be disposed in State-permitted solid waste disposal facilities with approval from the landfill operator. The SHWD shall be notified for a case-by-case determination of any volumes exceeding 20 tons from any single generator or transporter within any 90-day period.

3.2.2 For NORM/TENORM equipment exceeding measurements of 50 µR/hr or equivalent in other measurement units at any accessible point, the owner/operator has the option to sample and/or remove the material adhering to the equipment and re-survey the equipment. Subsequent equipment readings below this threshold allow recycle or disposal of the equipment as in 3.2.1 above.

If subsequent equipment readings are above 50 µR/hr or equivalent in other measurement units at any accessible point, any NORM scale, sludge or other wastes from the equipment should be sampled and analyzed. If the wastes removed and/or sampled from the equipment indicate levels less than 30 pCi/g, the equipment should be recycled or up to 20 tons may be disposed in State-permitted solid waste disposal facilities with approval from the landfill operator. If the wastes removed and/or sampled from the equipment indicate levels greater than 30 pCi/g, but less than 50 pCi/g, the equipment should be recycled or up to 10 tons may be disposed in State-permitted solid waste disposal facilities with approval from the landfill operator. The waste must be covered upon receipt at the landfill with a minimum 4 feet of approved cover material.

If the wastes removed and/or sampled from the equipment indicate levels greater than 50 pCi/g, the equipment must be managed at a facility outside Wyoming authorized for such low level radioactive material. Regulations of the Occupational Health and Safety Administration (OSHA) require all employers to evaluate radiation hazards and post caution signs where radiation doses could exceed 5 millirem in one hour or 100 millirem in any five consecutive days.

NORM INQUIRIES: Solid and Hazardous Waste Division

Cheyenne	307-777-7752	Casper	307-473-3450
Lander	307-332-6924	Sheridan	307-673-9337

Signed,

CA D — 8/12/11

Carl Anderson, PhD — Date
Administrator, Solid and Hazardous Waste Division (SHWD)